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Article

Competitiveness, innovation and productivity of the country

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COMPETITIVENESS, INNOVATION AND PRODUCTIVITY OF THE COUNTRY

Abstract. *This study discusses and investigates the key determinants of country competitiveness. An analysis of the available literature relating to the key determinants of the country's competitiveness makes it possible to mention that their determinants are not yet completely explored. The issue is that the current literature examines the impact of GDP per capita and human capital while omitting important factors affecting a country's competitiveness. Knowledge capital is one of the main factors of economic growth and competitiveness. Indigenous innovation contributes to the production of knowledge capital, while FDI and import trade are two major pathways for technological diffusion. As a result, when studying the causes of a country's competitiveness, the effects of these elements are not negligible. The following logical processes are used to investigate the topic of main factors of a country's competitiveness: first, a theoretical model outlining the primary factors of a country's competitiveness is studied; second, acceptable measurements for a country's competitiveness are selected; third, a balanced panel data set is created, and unknown parameter estimation is carried out. The GMM two-step panel data estimation technique is the major methodological instrument used in the article. Annual data from 2001 to 2020 on eight macroeconomic variables are included in the database (total 1040 observations per macroeconomic variable (52 countries, 20 years)). The study proved both practically and theoretically that: 1) the lagged value of the dependent variable has a positive and considerable impact on the competitiveness of the country; 2) the labor productivity of a country is an essential factor of competitiveness; the higher a country's labor productivity, the more probable it is to produce and export; 3) human capital and research and development are major sources of knowledge creation that directly contribute to a country's competitiveness; 4) the influence of FDI and imports on competitiveness has been proven to be significant; 5) weak institutions in emerging and developing economies have a negative impact on export sophistication and, as a result, a country's competitiveness. The research findings should be relevant to economic policymakers and model developers interested in estimating and evaluating structural systems of equations.*

Keywords: competitiveness, dynamic panel data model, export sophistication index, foreign direct investment, GMM system estimation, human capital, labor productivity.

Introduction. The key explanatory variables of a country's competitiveness are examined in this article. According to Lall et al. (2006), the measure of export sophistication index is used to analyze country competitiveness. A country that can export sophisticated products is a powerful competitor globally. Hausmann et al. (2007) made the second major contribution to research on a country's export sophistication and competitiveness level. According to Hausmann et al. (2007), the country is competitive if its resources are allocated to the most sophisticated products. As a result of these findings, one might conclude that the export sophistication index could be used to estimate a country's competitiveness. As a result, by examining the key determinants of the export sophistication index, this study can answer the question of what factors indirectly influence country competitiveness. The existing literature focuses on the significance of GDP per capita and human capital in terms of significant determinants. Still, it ignores

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essential aspects that could impact a country's level of export sophistication and, therefore, competitiveness. Knowledge capital, for example, has long been considered a key factor of economic growth and competitiveness (Romer, 1990). Knowledge capital is created through both local innovation and external technology transfer. R&D and education are the key sources of indigenous innovation, whereas FDI and import trade are two of the most important pathways for technology diffusion. The scientific evidence points to a link between innovation, global competitiveness, and economic growth (Tadevosyan, 2021).

Furthermore, as the correlation and regression analysis reveal, making investments is vital for developing one sector (e.g., tourism) and boosting its contribution to GDP (Tovmasyan, 2021). Therefore, it is worth evaluating the FDI impact as well. According to the analysis of export sophistication and competitiveness determinants, the effect of the listed factors is not negligible. Thus, these factors must be incorporated into the model. The specification of Hausmann et al.'s (2007) export sophistication model is changed in this study to account for lagged values of dependent variables and knowledge capital (R&D, FDI, and import trade). It should be noted that the econometric specification of the model becomes a dynamic panel data model when lagged values are included.

On the other hand, traditional panel data estimators become biased when lagged values are included in a model (Nicel, 1981). Furthermore, other econometric issues comparable to those outlined in Cameron and Trivedi (2005) and Roodman (2009). These difficulties include the possibility of autocorrelation in the error terms and the possibility that some explanatory factors are predefined and not random. Furthermore, suppose human capital and FDI are included as independent factors in the regression model. In that case, there may be plausible causal impacts from export sophistication to these variables, resulting in an endogeneity problem. The Arellano-Bond (1991) GMM estimator is widely employed to handle the above-described concerns because our panel has a short time (2001-2020) and a reasonably large number of cross-section observations (52 nations).

A novel panel dataset and substantially more successful estimating methods are used in this research. According to the findings, export sophistication (country competitiveness) is path-dependent, and labor productivity influences the dependent variable positively. The findings suggest that human capital and R&D are major sources of indigenous knowledge generation, which contribute directly to a country's rise in export sophistication. The influence of FDI and imports on export sophistication is found to be large and favorable. The quality of the institution has a detrimental impact. Finally, the endogeneity of human capital, FDI, and export sophistication is considered in this work.

Literature review. Lall et al. (2006) proposed a product-level export sophistication index that considers each exporter's income level (i.e., per capita GDP). Its principal feature is a new international classification system for products. This complexity classification connects each product to the exporter country's characteristics, providing a new way to assess a country's export structure and competitiveness. Lall et al. (2006) remarked the country is competitive if it exports advanced items with long-term and robust market prospects (i.e., products able to compete with others in the world market). Hausmann et al. (2007) provided the second major contribution to research on a country's level of export sophistication. They proposed the EXPY, a new export sophistication index. Hausmann et al. (2007) examined the relationship between export sophistication and a country's economic competitiveness. These scholars captured the productivity level linked with each country's export basket, building on the findings of Lall et al. (2006). While Lall et al. (2006) associated complexity with competitiveness, Hausmann et al. (20070 associated sophistication with productivity through a self-discovery process in which entrepreneurs identify their most productive activities and reallocate resources to the most advanced items. As a result, according to Hausmann et al. (2007), a country is competitive if its resources are dedicated to the most sophisticated products (i.e., those that are ranked higher on the Product Complexity Index).

Based on the above two contributions, it is feasible to conclude that export sophistication is an indirect indicator of a country's competitiveness. In other words, export sophistication could be used to assess a country's competitiveness. Following this goal, some academics seek out appropriate characteristics that influence export sophistication and, as a result, indirectly influence a country's competitiveness. First and foremost, the work by Hausmann et al. (2007) should be mentioned among these studies. The authors assess the impact of essential drivers on export sophistication and country competitiveness in their article. GDP per capita, human capital, the rule of law index, population, and land area could all be used as possible determinants of export sophistication. Four models were generated based on the regression, each with different explanatory factors. The outcomes vary depending on the model used.

The export sophistication index is regressed on a wide range of explanatory variables by Zhu et al. (2009). The authors examined the theoretical economic model to develop the export sophistication specification. This article identified three explanatory variables, including variables relating to a country's natural resources, human capital, foreign direct investment, economic size, and country institutional quality. Physical capital and knowledge generation via investment in education, R&D, foreign direct investment, and imports are the major determinants of export sophistication. On the other hand, the impact of natural resources on export sophistication depends on the quality of institutions in a given country. Thus, if the country's institutions are of high quality, the impact of natural resources on export sophistication may be positive, and vice versa. Cabral and Veiga (2010) found that GDP per capita and the size of the economy are both positively associated with export sophistication. Improvements in the institutional, political, and educational environment, on the other hand, may play a significant impact in boosting the degree of export sophistication and competitiveness in Sub-Saharan Africa. Lin et al. (2017) investigated whether export sophistication adds to the improvement of income in Sub-Saharan Africa. The authors showed that within-country differences in exports led to long-term economic development in the area. Cabral and Veiga (2010) further suggest that a high level of corruption in the country is one of the key factors restricting export sophistication. Finally, the rise in human capital is found to be positively connected with the level of export sophistication.

Weldemicael (2012) examined the relative significance of technology and trade costs on export sophistication and welfare. The findings reveal that the export sophistication index is positively and statistically significantly connected with GDP per capita, human capital, and nation size. Furthermore, compared to the effect of other explanatory factors, the lagged value of export sophistication has a dominant effect on export sophistication. The lagged value of export sophistication significantly influences the present value. Cross-country panel data was used to discover the effect of foreign direct investment on export sophistication is favorable for nations with low institutional quality. One of the paper's main conclusions is that the distance from major markets and the export sophistication index are adversely connected, not surprising. According to this study, institutional quality has a minor and minimal impact on export sophistication. There is evidence of productivity growth, the decline of the product price, and improvement of competitiveness. However, it is much dependent on other states' economies for small countries (Wulong and Beiling, 2016). At a firm level, productivity has a principal effect on competitiveness, and in the long run, it can affect the whole economy (Laureti and Viviani, 2011). A country's high competitiveness is very important since it helps the state have a more maintainable economy and eventually improve its living standards (Kharlamova and Vertelieva, 2013). According to Dresch et al. (2006), there is a direct connection between competitiveness and productivity, and the latest can be classified as the most dominant factor affecting competitiveness. It is important to mention that even labor productivity and economic growth do not constantly link with time. However, the increase in labor productivity substantially affects the economy (Auzina-Emsina, 2014). It should be noted that several elements affect productivity growth, in particular investments in innovations and human resources

(Wysokińska, 2003). Some research shows that export has a crucial effect on productivity and that the increase of production positively impacts productivity growth (Rijesh, 2019).

Moreover, there is a strong link between innovation and competitiveness: innovation can positively impact a country's competitiveness and economic growth (Sánchez et al., 2018). It is crucial as both fixed capital and intangible resources, such as knowledge, play a major role in economic growth and competitiveness, so many small countries can benefit from that opportunity (Jona-Lasinio and Meliciani, 2018). According to some authors, there is much theoretical evidence concerning the connection between innovation, productivity growth, and competitiveness. Nonetheless, there is a need for empirical confirmations (Lopes et al., 2014). Thus, in this paper, the empirical literature on export sophistication is expanded in three ways:

1) in the export sophistication model, the lagged value of a dependent variable and three other explanatory variables, like R&D, FDI, and import of goods and services, are included;

2) as an export sophistication index, three alternative measures (EXPY, ESI, and ECI) are used. Then exercising these three measures, robustness check analysis is conducted;

3) a new panel dataset (including COVID-19 pandemic) and more effective estimation algorithms are used for the model's estimation.

Methodology and research methods. The model is based on Hausmann et al. (2007), who assumed a two-sector economy with the traditional sector producing a homogeneous single good and the modern sector producing various goods. The modern sector has a high technological level. Because they are competitive, modern sector items are exported to the global market. Natural resources, labor, and physical capital are the three primary input variables of the modern sector. Thus the production function is:

$$Y = AL^{\alpha}K^{\beta}N^{\gamma} \quad (1)$$

where L, K, and N denote labor, capital, and natural resources, respectively; α+β+γ=1 is the output exhibits a constant return to scale; A is a technical level parameter for mixing these factors in the production process, distributed uniformly over the range $[0, \hat{A}]$ $\widehat{(A}$ is determined by a country's skill endowments).

Following Fagerberg (1988) and Sterlacchini (2008), it is assumed that $\hat{A}$ is the multiplicative function of the knowledge taken from domestic (D) and foreign (F) sources, the capability to reap the benefits of both kinds of knowledge (I) and the constant (B).

$$\hat{A} = BD^{\lambda_D}F^{\lambda_F}I^{\lambda_I} \quad (2)$$

The larger $\hat{A}$ is the higher level of the production frontier. No investors know with certainty whether the new products will have a high-productivity or a low-productivity level. The investors only know is that A obeys a uniform distribution. Once the new product has been developed, A becomes known. The firms could imitate productive products with a fraction θ $(0 < \theta < 1)$ without additional costs. Parallel to his or her own developed products, the investor could continue producing his or her own goods or reproduce the products with the highest productivity. The investor compares the productivity A_i of their own goods with the more productive good A^{max}. Only when the discovered productivity is higher than $A_i > \theta A^{max}$, the investor choose to stick with the new product developed by own efforts, and otherwise, he imitates the A^{max} – product. Additionally, the expectations of Amax depend on the productivity frontier and the number (m) of firms: $E(A^{max}) = \frac{m\hat{A}}{m+1}$. Hausmann et al. (2007) derived the following expectation for the A:

$$E(A) = \frac{1}{2}\hat{A}\left(1 + \left(\frac{\theta m}{m+1}\right)^2\right) \quad (3)$$

The expected productivity is a function of the number of investors engaged in cost discovery (m) and knowledge capital$(\widehat{A})$. After some algebra, the expected output could be presented as follows:

$$E(Y) = \frac{1}{2}B\left(1 + \left(\frac{\theta m}{m+1}\right)^2\right)D^{\lambda_D}F^{\lambda_F}I^{\lambda_I}L^{\alpha}K^{\beta}N^{\gamma} \quad (4)$$

Dividing both sides by L the following model could be put forward:

$$E\left(\frac{Y}{L}\right) = \frac{1}{2}B\left(1 + \left(\frac{\theta m}{m+1}\right)^2\right)D^{\lambda_D}F^{\lambda_F}I^{\lambda_I}\left(\frac{K}{L}\right)^{\beta}\left(\frac{N}{L}\right)^{\gamma} \quad (5)$$

Taking natural logarithms, it could be obtained:

$$\ln\left(\frac{Y}{L}\right) = \ln\left(\frac{1}{2}\right) + ln(B) + \ln\left(1 + \left(\frac{\theta m}{m+1}\right)^2\right) + \lambda_D ln(D) + \lambda_F ln(F) + \lambda_I ln(I) + \beta ln\left(\frac{K}{L}\right) + \gamma ln\left(\frac{N}{L}\right) \quad (6)$$

where $\frac{Y}{L}$ could be proxied with export sophistication index $(EXPY)$; domestic knowledge – with education and R&D; foreign knowledge – with FDI and imports; the knowledge – with the country's institutional, social and cultural features; capital and labor ratio – with labor productivity. Thus, taking into account these features and replacing $\frac{Y}{L}$ with $(EXPY)$, the basic model could be specified as follows:

$$ln(EXPY_{it}) = \beta_0 + \beta_1 \ln(LPROD_{it}) + \beta_2 \ln(LANDpc_{it}) + \beta_3 \ln(HC_{it}) + \beta_4(R\&Dg_{it}) + \beta_5 ln\,(FDIpc_{it}) + \beta_6(IMPg_{it}) + \beta_7 \ln(POP_{it}) + \beta_8 RofL_{it} + \nu_i + \varepsilon_{it} \quad (7)$$

where i denotes the country and ν_i - the cross-section fixed effect; ε_{it} is a random error term uncorrelated to the independent variables ν_i; Ln is the natural logarithm of matching variables; LPROD is labor productivity, which is proxied by industrial sector labor productivity; LANDpc is the land area per capita; R&Dg is the R&D expenditure as a percentage of GDP. The gross tertiary enrollment rate is used to calculate human capital (HC) (both sexes). One of the most important aspects of innovation in research and development.

The quantity of articles published in technical and scientific journals has a big impact on the quality of a country's science, which drives innovation (Fagerberg and Srholec, 2008). Based on this logic, it may be concluded that rising R&D spending generates new knowledge. The firms could use this new knowledge to develop new goods or improve existing ones, to remain competitive and profitable. As a result, R&D spending and the application of new information should become a key function for many businesses. From this perspective, including R&D expenditures (as a suitable indicator of innovation) in the model could explain the relationship between competitiveness and innovation via increased productivity. The last two variables represent a country's domestic knowledge endowment. The proportions of annual foreign direct investment stock (inward flow) and imports of goods and services in GDP are FDIpc and IMPg, respectively. The last two factors represent a country's foreign knowledge endowment. The term population refers to people living in a given country. Institutional quality, which is proxied by the 'rule of law index', is the final variable in the equation. In addition, the specification could

include the lagged value of the dependent variable. In some ways, a static model would be turned into a more realistic dynamic panel data model.

As was mentioned above, the export sophistication index could be used as a proxy for country competitiveness. Following Hausmann et al. (2007), the export sophistication index could be constructed in two steps.

Step 1. X_i^k is the export of product k from country i. Then, the total export of country i is equal to the sum of all products $X_i = \sum_k X_i^k$. When having the volume of export for the k-th product, it is possible to calculate the productivity (PRODY) associated with each product by the following formula:

$$PRODY^k = \sum_i \left\{ \frac{\left(X_i^k / X_i\right)}{\sum_i (X_i^k / X_i)} Y_i \right\} \quad (8)$$

where Y_i is the country's GDP per capita.

Step 2. The export sophistication index is calculated in this step, which is the average productivity level of the total export basket (EXPY). It can be done using the following weighted-average formula:

$$EXPY_i = \sum_k \left\{ \frac{X_i^k}{X_i} PRODY^k \right\} \quad (9)$$

Alternative export sophistication measures could also be employed as a robustness check, particularly Export Similarity Index (ESI) and Economic Complexity Index (ECI). Finger and Kreinin (1979) were the first to introduce the ESI, and Schott (2008) has lately revived it. According to this method, one country (or set of countries) could be identified as exporting high-productivity items when compared to other countries. This country (or a collection of countries) is regarded as the benchmark for export sophistication. The United States is used as a comparison country in this study. Then, given product p, the ESI between country A and the United States could be defined as follows:

$$(A - USA, p) = \sum_p 100 \times min\left(S_{Ap}, S_{USAp}\right) \quad (10)$$

where S_{USAp} is the percentage of product p in total exports from the United States. The ESI's higher value shows that exports from nation A are more similar to the export basket of the United States. A higher ESI rating suggests that country A has a better level of export sophistication. The ESI index is a number that ranges from zero to one.

Hidalgo and Hausman (2009) proposed the ECI. The authors use export statistics to try to gauge the economy's complexity. Unlike the previous two measures, however, the authors do not begin with the assumption that high-income countries export highly advanced items. The core premise is that any product necessitates a specific level of knowledge to be manufactured. The more expertise a product necessitates, the more complicated it becomes. The more distinctive items a country creates the more knowledge it is expected to have. It is referred to as diversity. The fewer countries that create a given product, the greater the amount of knowledge is required to make it. That is because only a few countries with the necessary information can do so. It is referred to as ubiquity. The amount of country knowledge is defined by its diversity and ubiquity. Thus, diversity is the number of products a country is connected to. Ubiquity is the number of countries a product is connected to. If country c has a Revealed Comparative Advantage (RCA) in product p, the matrix M_{cp} takes the value 1 and 0 otherwise. Then diversity and ubiquity could be defined by the following formula:

$$Diversity = k_{c,0} = \sum_p M_{cp} \quad (11)$$

$$Ubiquity = k_{p,0} = \sum_c M_{cp} \quad (12)$$

However, the authors point out that these measures should be corrected by each other using an iteration process, which is called the Method of Moment of Reflections. After N iterations, the complexity indices are computed as follows:

$$k_{p,N} = \frac{1}{k_{p,0}} \sum_c M_{cp} k_{c,N-1} \quad (13)$$

$$k_{c,N} = \frac{1}{k_{c,0}} \sum_p M_{cp} k_{p,N-1} \quad (14)$$

Then substituting $k_{p,N}$ into $k_{c,N}$ the following equation for economic complexity index is got:

$$k_{c,N} = \sum_{c'} \widetilde{M}_{cc'} k_{c',N-2}, \quad (15)$$

where $\widetilde{M}_{cc'} = \sum_p \frac{M_{cp} M_{c'p}}{k_{c,0} k_{p,0}}$. The iteration process stops when the relative rankings of iteration N and iteration N+2 are equal, meaning that $k_{c,N} = k_{c',N-2}$. It corresponds to the eigenvector of $\widetilde{M}_{cc'}$ associated with the largest eigenvalue. However, the authors pointed out that this eigenvector is a vector of ones and not informative.

To calculate the ECI index, it is necessary to take the eigenvector associated with the second largest eigenvalue $(\vec{K})$. This eigenvector is then normalized to have zero mean and variance equal to 1. To normalize the eigenvector, it is necessary to subtract its mean and divide by standard deviation. Finally, it is obtained the following ECI:

$$ECI = \frac{\vec{K} - \bar{\vec{K}}}{stdev(\vec{K})} \quad (16)$$

where $\vec{K}$ is the eigenvector associated with $\widetilde{M}_{cc'}$ second largest eigenvalue.

The International Trade Center database (ITC) was used to create all of the above export sophistication indexes. The export products' HS02, 4-digit classification is used as the basis for the calculation. There are 1258 products in this category. The value of exports is calculated in thousands of current US dollars, according to the ITC database. Year to year, the number of countries reporting their export volume varies. The PRODY and EXPY indexes are built for a balanced sample of 97 nations, taking this into account. The rationale for this is that from 2001 through 2020, these countries consistently disclose trade data every year. Table 1 presents the descriptive statistics for the EXPY dynamics.

Table 1. Descriptive statistics for EXPY (in US dollars)

Year	Num. Obs	Mean	StDev	Minimum	Maximum	Range
1	2	3	4	5	6	7
2001	97	15276.9	5005.5	2939.3	29063.6	26124.3
2002	97	15500.5	5083.8	2808.6	29090.5	26281.9
2003	97	15773.8	5116.2	2719.4	29424.2	26704.8
2004	97	16302.6	5450.2	3773.1	30419.1	26646.0
2005	97	16754.2	5383.6	3994.5	31283.7	27289.2

Continued Table 1

1	2	3	4	5	6	7
2006	97	17355.0	5372.5	3301.6	32466.3	29164.6
2007	97	17994.8	5470.0	4608.3	33831.4	29223.1
2008	97	18035.6	5379.0	3864.8	34676.6	30811.8
2009	97	17299.1	5302.9	3870.7	32349.5	28478.8
2010	97	17703.9	5211.5	4435.2	32657.5	28222.3
2011	97	17980.2	5328.4	5257.3	32621.0	27363.6
2012	97	18020.2	5042.4	4220.9	33368.6	29147.8
2013	97	18181.4	5190.4	4334.3	33518.0	29183.7
2014	97	18465.1	5040.0	5810.8	33140.2	27329.4
2015	97	18889.6	5507.2	3913.2	33191.6	29278.4
2016	97	19174.9	5559.7	6047.2	33626.6	27579.4
2017	97	19603.3	5650.4	4829.3	33746.7	28917.4
2018	97	19994.9	5858.7	4963.9	36813.3	31849.4
2019	97	20231.9	5892.5	4540.6	37540.5	32999.9
2020	97	19311.9	5820.6	4185.9	36529.0	32343.1

Sources: developed by the authors.

Table 1 shows that the standard deviation is relatively high, and EXPY is a large variation (Column 4). From 2001 to 2020, the EXPY significantly increased. Column 3 presents the average EXPY values for all countries (97 countries). Table 1 shows that EXPY increased from 15276.9 US dollars in 2001 to 19311.9 US dollars in 2020. During this period, the average growth rate of the EXPY was 1.2% per year. The average growth rate is calculated using the geometric mean formula. These figures allow concluding that during 2001-2020 the EXPY value for some low-income countries grew faster than in the high- and middle-income countries. This growth was small, and it is not enough for a significant increase in export sophistication and diversification structure. Thus, the export sophistication index established by Hausmann et al. (2007) is employed as a dependent variable in the main regression model, while two other measures (ESI and ECI) are used for robustness check analysis. Let's get started with the explanatory variables.

1. The value of industry added per worker is called labor productivity (PROD).
2. Land area per capita (LANDpc) is derived by dividing the population by the land area in square kilometers. The land area per capita in square kilometers is calculated due to dividing.
3. In percentage terms, the gross tertiary enrolment ratio is used to calculate human capital (HC). If this ratio is high, the economy's human capital is relatively higher.
4. The research and development (R&Dg) proportion in GDP shows the government's research and development spending as a percentage of total GDP. As previously stated, the HC and R&Dg indicate a country's internal knowledge endowment.
5. Foreign direct investment per capita (FDIpc) is the next explanatory variable (inward flow).
6. The import of goods and services in GDP (percent -th) (IMPg) reflects the percentage of total GDP from imported goods and services.
7. Population (POP) data is reported in millions of people. This variable represents the size of the economy. When the population is quite large, the economy is also larger.
8. The rule of law index (RofL) is a widely used indicator of institutional quality. Between -2.5 and 2.5, the index swings. A higher score indicates stronger governance and institutional quality.

The world development indicator provides information on labor productivity, land area, population, human capital, research and development, and the import of goods and services in GDP. The UNCTAD database is used to calculate the stock of foreign direct investment (inward flow). The WGI (Worldwide Governance Indicator) data on institutional quality were obtained from the World Bank. The rule of law,

government efficiency, and six additional institutional quality indexes are presented in this database for the years 1996, 1998, and 2000–2020. Many nations are dropped from the original samples because statistics for some variables (percentage of R&D investment in GDP, human capital, etc.) are unavailable in the major years of the sampling period. The regression analysis employed a total of 52 countries as the final sample.

Results. The econometric model developed in the previous section was utilized to estimate the regression equation for export sophistication and competitiveness. When the lagged value of the dependent variable is added to the above model, the following specification is obtained:

$$ln(EXPY_{it}) = \beta_0 + \beta_1 \ln(EXPY_{it-1}) + \beta_2 \ln(LPROD_{it}) + \beta_3 \ln(LANDpc_{it}) + \beta_4 \ln(HC_{it}) + \beta_5 (R\&Dg_{it}) + \beta_6 ln(FDIpc_{it}) + \beta_7 (IMPg_{it}) + \beta_8 \ln(POP_{it}) + \beta_9 RofL_{it} + \nu_i + \varepsilon_{it} \quad (17)$$

Several econometric issues may occur when estimating the above equation (Weldemicael, 2012). Empirical literature often finds significant endogeneity between FDI (or HC) and export sophistication (dependent variable). The endogeneity could be in both directions. Time – invariant country characteristics (fixed-effects) might be correlated with the explanatory variables. Including the lagged dependent variable in the model may result in autocorrelation in the error terms, resulting in biased fixed effect estimations (Nickell, 1981) Panel data has a small-time dimension (T = 20) but a big country dimension (N = 52).

The study looks at how these possible issues could be addressed at this stage. Fixed-effects instrumental variables estimate (two-stage least squares estimator) could be used to solve problem 1. To apply the 2SLS, firstly, it is necessary to identify the proper external exogenous factors. It is frequently impossible to do so in practical model estimation. The Arellano and Bond (1991) difference GMM system estimator is utilized for model estimation. To apply this estimator, the lagged values of the endogenous regressors must be included in the model (HC and FDIpc). The endogenous regressors become pre-determined as a result of inclusion and so are not connected with the error term. Using first differences, problem 2 (fixed effects) could be solved. As a result of first differencing, the following equation is got:

$$\Delta ln(EXPY_{it}) = \beta_0 + \beta_1 \Delta \ln(EXPY_{it-1}) + \beta_2 \Delta \ln(LPROD_{it}) + \beta_3 \Delta \ln(LANDpc_{it}) + \beta_4 \Delta \ln(HC_{it}) + \beta_5 \Delta(R\&Dg_{it}) + \beta_6 \Delta ln(FDIpc_{it}) + \beta_7 \Delta(IMPg_{it}) + \beta_8 \Delta \ln(POP_{it}) + \beta_9 \Delta RofL_{it} + \varepsilon_{it} \quad (18)$$

In the result of first differencing the fixed effect is removed because the fixed effect does not vary with time. Thus, it is got:

$$\Delta u_{it} = \Delta \nu_i + \Delta \varepsilon_{it} \quad (19)$$

$$u_{it} - u_{i,t-1} = (\nu_i - \nu_i) + (\varepsilon_{it} - \varepsilon_{i,t-1}) = \varepsilon_{it} - \varepsilon_{i,t-1} \quad (20)$$

The first difference delayed dependent variable is instrumented with its historical levels to solve problem 3. Finally, the Arellano-Bond estimator was created for [panels (problem)] with small T and big N. As can be seen from the examples above, the Arellano-Bond difference GMM estimator can solve all four econometric issues since it is used to estimate the model's unknown parameters. The STATA xtabond2 command (Roodman, 2009) was used to estimate the model. Table 2 lists the results.

Table 2 illustrates the Arellano-Bond two-step GMM estimation results for all countries included in our analysis. In Table 2, the autocorrelation tests of the residuals show no significant autocorrelation. Table 2 indicates that lagged value of the dependent variable has a significant and positive impact on the current

value. In addition, the lagged value of the dependent variable has a dominant impact on the current value compared with the other explanatory variables.

Table 2. Empirical results from Arellano-Bond two-step estimation for all sample countries (Dependent variable ln(EXPY) export sophistication)

	1	2	3	4	5
ln(EXPYit-1)	0.3457***	0.3741***	0.3814***	0.3758***	0.3645***
	(0.0270)	(0.0250)	(0.0260)	(0.0264)	(0.0261)
ln(LPRODit)	0.2057***	0.1892***	--	--	0.2153***
	(0.0164)	(0.0164)	--	--	(0.0174)
Ln(LANDpcit)	-0.0274	-0.1119	-0.2216	-0.1939	-0.0415
	(0.3931)	(0.4025)	(0.4271)	(0.4264)	(0.3929)
HCit	0.0009***	0.0012***	0.0013***	0.0013***	0.0008***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
R&Dgit	0.0215***	--	0.0343***	0.0329***	0.0220***
	(0.0084)	--	(0.0091)	(0.0091)	(0.0084)
ln(FDIpcit)	0.0402***	0.0495***	0.0786***	0.0762***	0.0404***
	(0.0049)	(0.0048)	(0.0042)	(0.0044)	(0.0049)
IMPgit	0.0016***	--	--	--	0.0016***
	(0.0002)	--	--	--	(0.0002)
Ln(POPit)	0.1495	0.0407	-0.1212	-0.0635	0.1158
	(0.3987)	(0.4081)	0.4328	(0.4328)	(0.3988)
RofLit	--	--	--	-0.0318**	-0.0238*
	--	--	--	(0.0146)	(0.0143)
Num of Obs	1040	1040	1040	1040	1040
Num of Countries	52	52	52	52	52
Num of Instr	38	38	38	38	38
AR(2)	0.265	0.124	0.325	0.325	0.265
Hansen Test	0.326	0.412	0.521	0.365	0.425

Notes: Standard errors are provided in parenthesis below the respective estimated coefficients.
, ** and * indicate respectively significance levels of 10%, 5%, and 1%.*
Sources: developed by the authors.

Table 2 shows separate regressions are run excluding and including the rule of law index. The estimated results are reported in columns 1-3 (excluded) and 4-5 (included). To keep robustness of our results, it was also experimented with different specifications dropping IMPg, R&Dg, and LPROD from the full equation. The LPROD significantly and positively impacts export sophistication. It could be concluded that if labor productivity is changing by 1%, the export sophistication will change by about 0.20%. The coefficient of land area per capita is negative and not significant. The coefficient of human capital is positive and statistically significant. The coefficient shows that if education is changed by 1%, export sophistication will be by 0.0012%. The coefficients of R&Dg are also positive and statistically significant. Finally, the country's size has both positive and negative impacts on export sophistication. The results are not statistically significant and not robust across different model specifications. The coefficients of institutional quality are statistically significant and negatively affect export sophistication.

It is reasonable also to use an augmented version of the Arellano-Bond GMM estimator – «System GMM» (Blundell and Bond, 1998; Baum, 2006; Roodman, 2009). Table 3 presents the results of system GMM estimation. The autocorrelation test of residual shows no significant second-order autocorrelation. Table 2 conducted the same regressions scheme. The lagged value of the dependent variable has a positive and significant impact on the current value.

Table 3. Empirical results from system GMM two-step estimation for all sample countries (Dependent variable ln(EXPY) export sophistication)

	1	2	3	4	5
ln(EXPYit-1)	0.3780***	0.3741***	0.3814***	0.4104***	0.4645***
	(0.0254)	(0.0221)	(0.0275)	(0.0312)	(0.0161)
ln(LPRODit)	0.1530***	0.1410***	--	--	0.1696***
	(0.0160)	(0.0150)	--	--	(0.0165)
Ln(LANDpcit)	0.0102	-0.0025	0.0034	0.0020	0.0150
	(0.0170)	(0.0157)	(0.014)	(0.0140)	(0.0160)
HCit	0.0010***	0.0013***	0.0013***	0.0013***	0.0009***
	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0003)
R&Dgit	0.0200***	--	0.0363***	0.0336***	0.0210***
	(0.0081)	--	(0.0083)	(0.0084)	(0.0080)
ln(FDIpcit)	0.0524***	0.0600***	0.0828***	0.0814***	0.0510***
	(0.0045)	(0.0044)	(0.0038)	(0.0040)	(0.0045)
IMPgit	0.0014***	--	--	--	0.0014***
	(0.0002)	--	--	--	(0.0002)
Ln(POPit)	0.0517***	0.0366***	0.0241**	0.0280**	0.0440***
	(0.0129)	(0.0120)	(0.0106)	(0.0109)	(0.0130)
RofLit	--	--	--	0.0215*	-0.0400***
	--	--	--	(0.0124)	(0.0130)
Num of Obs	1040	1040	1040	1040	1040
Num of Countries	52	52	52	52	52
Num of Instr	49	49	49	49	49
AR(2)	0.365	0.258	0.415	0.256	0.356
Hansen Test	0.224	0.312	0.421	0.310	0.254

Notes: Standard errors are provided in parenthesis below the respective estimated coefficients.
, ** and * indicate respectively significance levels of 10%, 5%, and 1%.*

Sources: developed by the authors.

Table 3 shows that labor productivity has a significant positive impact on export sophistication. Furthermore, Table 3 shows that a 1% change in labor productivity could cause about a 0.15% change in export sophistication level. This result is quite comparable with the corresponding results in Table 2. The estimated coefficient of land area is non-significant for all model specifications. These results also coincide with the ones in Table 2. In turn, the estimated coefficient for education is positive and significant for all model specifications. One can see that a 1% change in education level could cause a change in the export sophistication level about 0.001%, which is quite a small number. It is almost the same as in Table 2. The estimated coefficient for R&D is again positive and significant for all model specifications. It is seen that a 1% change in R&D could cause changes in export sophistication by 0.03%, which is again a relatively small number. In turn, it is larger than the coefficient for education. External knowledge components (FDI and impg) positively and significantly impact. The size of the economy has a significant positive impact. The estimated coefficient for institutional quality is significant, but the sign is not robust across different model specifications. Thus, as it could be concluded, almost all (except for population variable) estimated parameters coincide with the corresponding parameters in Table 2.

Other export sophistication measures are also employed to check the robustness of our analysis. Export similarity index (ESI) (Lin et al., 2017) and Economic Complexity Index (ECI) (Hidalgo and Hausman, 2009) were used, presented in the previous section. The dependent variable changed, and all other explanatory variables were kept the same as in the previous model. Also, the model specifications are kept. Thus, changing the dependent variable, Arellano-Bond and system GMM two-step estimations are run. The corresponding results are presented below, in Tables 4-7.

Table 4. Empirical results from Arellano-Bond two-step estimation for all sample countries (Dependent variable ln(ESI) Export Similarity Index)

	1	2	3	4	5
ln(ESIit-1)	0.3410***	0.3674***	0.3764***	0.3875***	0.3547***
	(0.0201)	(0.0215)	(0.0211)	(0.0217)	(0.0225)
ln(LPRODit)	0.2068***	0.2027***	--	--	0.2496***
	(0.0242)	(0.0237)	--	--	(0.0255)
Ln(LANDpcit)	0.2676	0.2451	0.0980	0.0677	0.2071
	(0.6159)	(0.6153)	(0.6372)	(0.6370)	(0.6089)
HCit	0.0023***	0.0022***	0.0020***	0.0020***	0.0025***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
R&Dgit	0.0126***	--	0.0163***	0.0178***	0.0143***
	(0.0030)	--	(0.0034)	(0.0034)	(0.0028)
ln(FDIpcit)	0.0315***	0.0337***	0.0666***	0.0692***	0.0324***
	(0.0071)	(0.0068)	(0.0058)	(0.0061)	(0.0070)
IMPgit	0.0015***	--	--	--	0.0014***
	(0.0004)	--	--	--	(0.0004)
Ln(POPit)	0.3047	0.3332	-0.5511	-0.6148	0.4542
	(0.6234)	(0.6227)	(0.6445)	(0.6452)	(0.6169)
RofLit	--	--	--	-0.0731**	-0.1039***
	--	--	--	(0.0208)	(0.0211)
Num of Obs	1040	1040	1040	1040	1040
Num of Countries	52	52	52	52	52
Num of Instr	38	38	38	38	38
AR(2)	0.125	0.212	0.245	0.198	0.205
Hansen Test	0.214	0.310	0.157	0.241	0.114

Notes: Standard errors are provided in parenthesis below the respective estimated coefficients.
, ** and * indicate respectively significance levels of 10%, 5%, and 1%.*
Sources: developed by the authors.

Table 5. Empirical results from system GMM two-step estimation for all sample countries (Dependent variable ln(ESI) Export Similarity Index)

	1	2	3	4	5
ln(ESIit-1)	0.3870***	0.3147***	0.3419***	0.4421***	0.4524***
	(0.0243)	(0.0232)	(0.0257)	(0.0321)	(0.0153)
ln(LPRODit)	0.2194***	0.2137***	--	--	0.2522***
	(0.0237)	(0.0231)	--	--	(0.0251)
Ln(LANDpcit)	0.0326	0.0355	0.0367	0.0371	0.0376
	(0.0592)	(0.0597)	(0.0642)	(0.0661)	(0.0636)
HCit	0.0025***	0.0024***	0.0021***	0.0021***	0.0026***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
R&Dgit	0.0280***	--	0.0186***	0.0189***	0.0244***
	(0.0030)	--	(0.0033)	(0.0013)	(0.0013)
ln(FDIpcit)	0.0212***	0.0243***	0.0594***	0.0598***	0.0226***
	(0.0072)	(0.0069)	(0.0059)	(0.0061)	(0.0071)
IMPgit	0.0016***	--	--	--	0.0015***
	(0.0004)	--	--	--	(0.0004)
Ln(POPit)	0.0323***	0.0318***	0.0711***	0.0738***	0.0604***
	(0.0121)	(0.0093)	(0.0145)	(0.0161)	(0.0143)
RofLit	--	--	--	-0.048**	-0.0803***
	--	--	--	0.0211	0.0213

Continued Table 4

	1	2	3	4	5
Num of Obs	1040	1040	1040	1040	1040
Num of Countries	52	52	52	52	52
Num of Instr	38	38	38	38	38
AR(2)	0.297	0.289	0.387	0.256	0.347
Hansen Test	0.210	0.247	0.358	0.287	0.210

Notes: Standard errors are provided in parenthesis below the respective estimated coefficients.
, ** and * indicate respectively significance levels of 10%, 5%, and 1%.*
Sources: developed by the authors.

Table 6. Empirical results from Arellano-Bond two-step estimation for all sample countries (Dependent variable ln(ECI) Economic Complexity Index)

	1	2	3	4	5
ln(ECIit-1)	0.2412***	0.1997***	0.2110***	0.2142***	0.2012***
	(0.0115)	(0.0189)	(0.0201)	(0.0227)	(0.0211)
ln(LPRODit)	0.1666***	0.1358***	--	--	0.1024**
	(0.0473)	(0.0477)	--	--	(0.0503)
Ln(LANDpcit)	0.3655	0.3514	3.6494	3.6007	0.3633
	(1.2022)	(1.2403)	(1.2036)	(1.2144)	(1.2022)
HCit	0.0017***	0.0012***	0.0011***	0.0012***	0.0013***
	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
R&Dgit	0.0201***	--	0.0197***	0.0213***	0.0202***
	(0.0025)	--	(0.00252)	(0.0025)	(0.0025)
ln(FDIpcit)	0.0099***	0.0198***	0.0032***	0.0071***	0.0102***
	(0.0014)	(0.0014)	(0.0011)	(0.0011)	(0.0014)
IMPgit	0.0013***	--	--	--	0.0013***
	(0.0007)	--	--	--	(0.0007)
Ln(POPit)	0.3596	0.3447	0.3601	0.3498	0.3543
	(1.2169)	(1.2551)	(1.2174)	(1.2192)	(1.2185)
RofLit	--	--	--	-0.05326	-0.03706
	--	--	--	(0.0392)	(0.0417)
Num of Obs	1040	1040	1040	1040	1040
Num of Countries	52	52	52	52	52
Num of Instr	38	38	38	38	38
AR(2)	0.125	0.212	0.245	0.198	0.205
Hansen Test	0.214	0.31	0.157	0.241	0.114

Notes: Standard errors are provided in parenthesis below the respective estimated coefficients.
, ** and * indicate respectively significance levels of 10%, 5%, and 1%.*
Sources: developed by the authors.

Table 7. Results from system GMM two-step estimation for all sample countries(Dependent variable ln(ECI) Economic Complexity Index)

	1	2	3	4	5
ln(ECIit-1)	0.1402***	0.1567***	0.1410***	0.1542***	0.1601***
	(0.0115)	(0.0179)	(0.0201)	(0.0212)	(0.0145)
ln(LPRODit)	0.1682***	0.1449***	--	--	0.1126***
	(0.0440)	(0.0449)	--	--	(0.0475)
Ln(LANDpcit)	-0.0403	-0.0516	-0.0540	-0.0517	-0.0380
	(0.0604)	(0.0637)	(0.0606)	(0.0614)	(0.0610)
HCit	0.0015**	0.0013**	0.0013*	0.0015*	0.0015*

Continued Table 7

	1	2	3	4	5
	(0.0008)	(0.0008)	(0.0007)	(0.0008)	(0.0008)
R&Dgit	0.02043***	--	0.0214	0.0205***	0.0215
	(0.0025)	--	(0.0246)	(0.0247)	(0.0249)
ln(FDIpcit)	0.0330**	0.062***	0.026**	0.0330**	0.035**
	(0.0131)	(0.0131)	(0.0105)	(0.0107)	(0.0131)
IMPgit	0.0015**	--	--	--	0.0015**
	(0.0007)	--	--	--	(0.0007)
Ln(POPit)	0.0358	0.0286	0.0188	0.0159	0.0330
	(0.0482)	(0.0504)	(0.0477)	(0.0490)	(0.0491)
RofLit	--	--	--	-0.0101	-0.0131
	--	--	--	(0.0370)	(0.0397)
Num of Obs	1040	1040	1040	1040	1040
Num of Countries	52	52	52	52	52
Num of Instr	38	38	38	38	38
AR(2)	0.125	0.212	0.245	0.198	0.205
Hansen Test	0.214	0.31	0.157	0.241	0.114

Notes: Standard errors are provided in parenthesis below the respective estimated coefficients.
, ** and * indicate respectively significance levels of 10%, 5%, and 1%.*
Sources: developed by the authors.

Based on Tables 4, 5, 6, and 7, it can be said that the sign and significance level coincide with the results of Tables 2 and 3. Hence, the comparison in Tables 4, 5, 6, and 7 shows robust findings. In other words, based on Tables 4–7, the same conclusions can be made that has been made based on Tables 2-3.

Conclusions. Several studies have been conducted on developing indices to quantify export sophistication and quality in recent years. However, their determinants have yet to be completely investigated. The purpose of this study article is to fill that void. A cross-country panel dataset covering the years 2001-2020 is evaluated for this purpose. There are 52 countries in the dataset, including developed, emerging, and developing countries. As can be seen, the time period includes both the global financial crisis (2008-2009) and the COVID-19 epidemic. According to Lall et al. (2006) and Hausmann et al. (2007), the export sophistication metric is used to examine the country's competitiveness. Nations' export sophistication is assessed using data for 101 countries from 2001 to 2020. Three types of export sophistication measures are calculated in this paper: the Hausmann et al. (2007) index, the Export Similarity Index, and the Economic Complexity Index. The findings show that the lagged value of the dependent variable has a positive and significant impact on export sophistication. This research demonstrates that export sophistication has a strong persistence behavior. Furthermore, the data imply that a country's labor productivity is a significant factor of export sophistication; the greater a country's labor productivity, the more probable it is to create and export more sophisticated commodities. As measured by land area per capita, natural resources have a minor impact on export sophistication. Human capital and R&D are major sources of knowledge development that directly contribute to countries' increasing export sophistication. FDI and imports are proven to have a strong beneficial impact on export sophistication as the key conduits of international knowledge transfer. The necessity of increasing the quality of formal institutions is demonstrated once again by our findings.

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Конкурентоспроможність, інновації та продуктивність країни

У рамках даного дослідження, авторами проаналізовано ключові детермінанти конкурентоспроможності країни. Авторами відмічено у дослідженнях з означеної тематики існують низка теоретичних розривів. За результатами систематизації наукових напрацювань встановлено, що здебільшого наукова спільнота розглядає ВВП на душу населення та людський капітал, як головні детермінанти конкурентоспроможності країни. Інтелектуальний капітал є одним із ключових факторів економічного зростання та конкурентоспроможності країни. При цьому інстинктивні інновації сприяють виробництву інтелектуального капіталу, тоді як прямі іноземні інвестиції та імпорт є основою технологічного розвитку. Таким чином, авторами наголошено, що зазначені вище фактори мають бути враховані при дослідженні конкурентоспроможності країни. З метою аналізу головних детермінант конкурентоспроможності країни, дослідження здійснено в наступній логічній послідовності: 1) проаналізовано теоретичні напрацювання з досліджуваної тематики; 2) визначено оптимальні змінні для оцінювання конкурентоспроможності країни; 3) сформовано збалансований набір панельних даних та проведено оцінювання невідомих параметрів. Методологічною основою дослідження є узагальнений метод моментів. Емпіричне дослідження проведено на основі панельних даних, сформованих для вибірки з 52 країн за 2001-2020 роки по восьми макроекономічних змінним (всього 1400 спостережень по кожній змінній). За результатами дослідження, авторами зроблено такі висновки: 1) лагове значення залежної змінної має значний та позитивний вплив на конкурентоспроможність країни; 2) продуктивність праці є суттєвим фактором конкурентоспроможності країни, при цьому чим вище рівень продуктивності праці, тим більшою є ймовірність виробництва та експорту; 3) людський капітал і дослідження та розробки є основою генерації знань, які сприяють підвищенню конкурентоспроможності країни; 4) прямі іноземні інвестиції та імпорт впливають на конкурентоспроможність країни; 5) слабкі інститути в розвинутих країнах та країнах, що розвиваються мають негативний вплив на експорт та, як наслідок, конкурентоспроможність країни. Результати дослідження мають практичне значення та можуть бути корисними при формуванні економічної політики розвитку країни.

Ключові слова: конкурентоспроможність, динамічна модель панельних даних, індекс експортної складності, прямі іноземні інвестиції, узагальнений метод моментів, людський капітал, продуктивність праці.